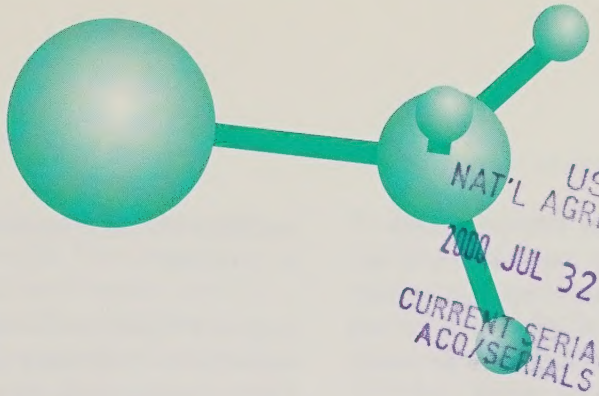
Methyl Bromide *Alternatives*



USDA

Vol. 6, No. 3
July 2000

Inside This Issue

This issue and all back issues of the *Methyl Bromide Alternatives* newsletter are now available on the Internet at **<http://www.ars.usda.gov/is/np/mba/mebrhp.htm>**.
Visit the ARS methyl bromide research homepage at **<http:/www.ars.usda.gov/is/mb/mebrweb.htm>**.

This newsletter provides information on research for methyl bromide alternatives from USDA, universities, and industry.

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What If . . .? The Strawberry Industry Without Methyl Bromide

Methyl bromide has been the cornerstone of many growers' pest management practices. But in January 2001, the amount of the soil fumigant available to them will be 50 percent of 1991 production levels—a decrease that could reduce yields.

Taken a step further, what if methyl bromide were suddenly unavailable? This scenario was presented recently to a select group of extension agents, growers, and researchers in the strawberry industry. A synopsis of their responses follows.

Two themes emerged: the efficacy of other chemicals compared with methyl bromide, and the lack of EPA registration for alternatives.

Soil Fumigation Alternatives

Soil fumigation accounts for 80 percent of methyl bromide usage. The main alternatives are combinations of chemicals: primarily Telone mixed with chloropicrin, Vapam with chloropicrin, or metam sodium with chloropicrin. Telone is most likely the front-runner, but it has drawbacks.

"In Florida, Telone is the most effective soil treatment, but farmers are squeezed by regulated buffer zones," explains Joseph Noling, an extension nematologist with the University of Florida's Institute of Food and Agricultural Services at Lake Alfred. In order to apply Telone in Florida, 300-foot buffer zones are required on agricultural lands abutted by occupied structures.

So, on a 22-acre rectangular farm surrounded by occupied structures, the farmer could grow only on the center 8 acres, according to Noling, adding pressure to an already tense situation.

Growers are keenly aware of the status of methyl bromide alternatives. "Right now, it looks like Telone/chloropicrin with an herbicide is the best alternative, but still not a very good one," says Marvin Brown, a strawberry grower in Florida. "And, unfortunately, many growers have no experience with Telone."

According to Florida extension agent Charles Hinton, "Cultural practices, such as cover crops and solarization, work only under ideal conditions. One hurricane can undo all the preparation work done during the summer."

In California, Vapam, Telone, and chloropicrin are the weapons of choice. But, Telone, a very good nematicide, can be used there only on an extremely limited basis because of regulatory restrictions. Caps limit Telone use in a township to 5,000 to 9,000 gallons per

year and require 300-foot buffer zones. Once the cap is reached, no more Telone can be applied within the township borders, which means the chemical is not available to the remaining growers there.
Vapam, identified as a carcinogen by California, is on the state's Proposition 65 list. (Proposition 65, also called the Safe Drinking Water and Toxic Enforcement Act of 1986, was a voter initiative passed to address citizen concerns about carcinogens and teratogens. The law prohibits businesses from discharging these chemicals into sources of drinking water and requires that warnings be given to individuals exposed to them.) Growers must have buffer zones and notify nearby landowners before they apply Vapam. Steve Fennimore, extension vegetable weed control specialist, University of California, Davis, says, "growers can administer chloropicrin followed by Vapam in drip lines in order to provide weed and disease control."

Another demerit for Telone is explained by Tommy Brock, a strawberry grower, of Plant City, Florida. "I've been treating with Telone for 3 years and find it has no residual effects, while methyl bromide leaves some residual effects for 3 to 5 years," he says.

In California, several materials are considered as possible alternatives, but they are not registered for pesticide use by EPA. These include Basamid, Vorlex (methylisothiocyanate plus 1,3–D), propargyl bromide, and methyl iodide. According to Frank Westerlund of the California Strawberry Commission, two materials stand out: "Efficacy studies to date show propargyl bromide and methyl iodide have the required spectrum of activity, and registration is needed as soon as possible."

Before it registers new active ingredients, California requires EPA registration and specific toxicological tests. EPA takes several years to register a new chemical, provided toxicological and environmental data are acceptable; any tests California might require add more time.

Herbicide Alternatives

Very few herbicide alternatives to methyl bromide are available for strawberries in Florida. Growers primarily spray Roundup between rows, since Devrinol doesn't seem to be very effective, according to Hinton. Some growers apply paraquat between rows to control weeds, while others use Vapam in drip irrigation. But these treatments add a step to field preparation and sometimes require new equipment.

Herbicides can also be added to Telone. "You can add an herbicide to Telone to get some weed control, although it is not as good as methyl bromide," contends Brock, who double-crops his strawberries with cherry tomatoes. This less effective weed control adds to his costs because workers must pull emerging weeds.

In California, Devrinol is the only material registered for application on strawberries. According to Westerlund, phytotoxicity problems and yield loss limit use of this chemical. Some farmers successfully use Devrinol for weed control in furrows but not in the crop. Other herbicides are either under evaluation or were eliminated as alternatives because of toxicology issues.

Fungicide Alternatives

Chloropicrin is relied on as a soil fungicide in both California and Florida. If this all-purpose fungicide fails to do the job, growers apply a species-specific fungicide. No other fungicides are on the horizon for future registration.

Economic Impact

Potentially, the strawberry industry could sustain the largest economic hit from the loss of methyl bromide. The industry will feel significant impacts in California and Florida, according to an economic model developed by John VanSickle, Charlene Brewster, and Thomas H. Spreen of the Cooperative Extension Service at the University of Florida, Gainesville.

Application of the model to Florida assumed use of a combination of Telone C17 (Telone with 17 percent chloropicrin) and Devrinol as a replacement for methyl bromide. This alternative anticipated a $71-per-acre decrease from preharvest costs and a 15-percent decrease in yields. This translates into preharvest costs increasing from $3.75 to $4.37 per flat. The low end of the economic impact estimated a 10-percent reduction in yields and the high impact, a 20-percent reduction in yields.

In the California scenario, the model used chloropicrin as the methyl bromide replacement, along with hand weeding. The expected impact of this alternative would be a $654-per-acre increase in preharvest costs and a 20-percent decline in yields, meaning per-unit preharvest costs would increase from $3.59 to $4.73. The lowest estimate is a 10-percent reduction in yields and the highest

is a 30-percent reduction in yields. VanSickle theorizes, "The use of labor instead of chemicals for weeding equals higher production costs, which would make California growers noncompetitive."

The model predicts that strawberry production in California would be particularly at risk, given the current state of knowledge about methyl bromide alternatives. Developing better alternatives is of paramount concern to strawberry growers. "We're relying on the university system and researchers to come up with a viable option," concedes strawberry grower Marvin Brown.

California Proposes New Regulations for Methyl Bromide Use

The California Department of Pesticide Regulations (DPR) has issued proposed regulations governing the use of methyl bromide as a soil fumigant. The regulations would require specific buffer zones, provide special protections for schools that abut farmland, and reduce workers' exposure times. Coupled with the January 2001 deadline for a 50-percent reduction in available methyl bromide, these regulations would pose major challenges for California produce growers.

Unlike the U.S. Environmental Protection Agency mandate to phase out methyl bromide to protect the ozone layer, the California DPR is acting to protect workers from the fumigant's toxic effects.

The proposed regulations would require users to obtain site-specific permits from the county agricultural commissioner before using methyl bromide. The commissioner could then require specific use practices. The regulations would further mandate a two-stage use notification plan and a mandatory minimum buffer zone of 100 feet. Users would have to notify those on "sensitive sites," such as homes, schools, and hospitals, of the intent to fumigate. Sensitive sites are those within 300 feet of the buffer zone boundary where methyl bromide is applied. The regulations would give these property owners the right to ask for a second notification 48 hours before the scheduled fumigation.

During four public hearings, growers noted that California's current guidelines for methyl bromide use are the nation's most stringent. But the guidelines, which are not mandatory or monitored, were deemed too vague and unenforceable. "This is the culmination of a years-long process of data gathering and analysis," says DPR Director Paul E. Helliker. "Methyl bromide, because of its toxicity, has been subject to increasingly tight restrictions by DPR since 1992, in the form of discretionary controls set at the county level. However, with new data on risks and exposure, we now have the solid scientific basis the law requires for statewide environmental regulations."

Last year, a San Francisco Superior Court judge ordered DPR to adopt by June 2000 more specific regulations for methyl bromide soil fumigation. Because of extended comment periods and an additional public hearing, DPR has requested a 4-month extension to that deadline.

At the public hearings, many California growers questioned whether the proposed size and duration of the buffer zones are based on qualified studies. The Western Growers Association (WGA) commented, "The proposed 60-hour buffer zone durations are not supported by data, are overly stringent, and would unnecessarily extend the total time it will take to fumigate a grower's acreage."

The group added, "WGA believes that the current 24-hour duration in which buffer zone restrictions are maintained is adequate and protective of public health. . . . Proposing a 60-hour duration for tarped inner buffer zone is unjustifiable." Eric Lauritzen, Monterey County agricultural commissioner and president of the California Agricultural Commissioner and Sealers Association, testified, "As our office is charged with enforcing related laws and regulations, it is always our interest to revive the proper and safe use of pesticides. Therefore, I urge your careful consideration of the available peer-reviewed scientific data, then to adopt regulations grounded in fact that provide measurable increased safety and ones that are enforceable." He continued, "I believe regulations should be reserved for prescriptive requirements. Our current restricted-materials permit process works very effectively in dealing with site-specific concerns, taking into consideration local conditions."

Increasing buffer zones is of particular concern to growers. Doug Buessing of Tri Cal, Inc., Hollister, California, testified, "The growers will likely suffer a 20-percent loss of fumigated ground on 30 acres; that's one-fifth of production."

Larger and longer-lived buffer zones will dramatically increase the number of days required to complete fumigation and will have a detrimental effect, according to WGA. For instance, a grower who is double-cropping strawberries and lettuce depends on the moisture from lettuce that is disked under to prepare the soil for fumigation before planting strawberries. Under current guidelines, it takes 12 days to fumigate the soil, block by block. After disking, the lettuce may provide just enough moisture for effective methyl bromide application. But under the new regulations, it could take 20 days to fumigate, leaving the soil dried out. If that happens, the grower would have to irrigate to provide the necessary moisture. The labor required for this task would adds significantly to a grower's costs.

Another point of contention is the proposed limit on employees' hours. Work hours for nontarped, shallow-bed applications would be limited to 4 hours in a 24-hour period. Currently, employees can work 8 hours in any 24-hour period. For tarped, deep broadcast applications, workers would be limited to 3 hours in a 24-hour period. Under current conventions, these employees can work 12 hours.

Time limits on work hours is a severe blow to growers and workers alike. It will take longer to fumigate fields because of a shortage of qualified drivers, and workers will be paid for fewer hours.

Growers contend the proposed regulations would create undue hardship. "California standards are currently at least eight times stricter than those of the federal government and the rest of the country, making the added regulations even more burdensome to California growers who must compete with the rest of the country and the world's farmers," claimed one farmer.

Growing Wheat in Apple Orchards: A Possible Aid in Preventing Replant Disease

Growers of the nation's largest crop of apples—in Washington State—may benefit by planting another of the Pacific Northwest's top commodities: wheat.

But the wheat in this case wouldn't be a typical for-profit crop. Grown instead as a rotation crop or cover crop in the orchard, it might help prevent replant disease, a crippling condition that strikes young orchards. And it could serve as an alternative to methyl bromide and other soil fumigants typically used to sterilize old orchards before planting new ones.

The idea comes from Mark Mazzola, a plant pathologist at the Agricultural Research Service's Tree Fruit Research Laboratory in Wenatchee, Washington. He's discovered that in the Pacific Northwest, replant disease seems to be caused by buildup of a complex of four soilborne fungi: *Cylindrocarpon, Phytophthora, Pythium,* and *Rhizoctonia*.

"Apple trees seem to change the soil in a way that favors these pathogens," Mazzola says. "Some wheat varieties, on the other hand, modify the soil environment to the benefit of different microorganisms."

Specifically, he found a bacterium, *Pseudomonas putida,* in some wheat soils that can protect young apple roots from the fungi. ARS has patented use of a strain of the bacterium to prevent replant disease.

Searching for Root Causes

When nothing is done between taking out an old orchard and putting in a new one, the young trees are often stunted and have small, decayed root systems. For years, scientists have debated whether the cause was biological—a disease or organism—or a result of abiotic factors, such as soil chemistry.

"Since methyl bromide and fungicides that suppress microbes seem to improve apple trees' health, it now looks like the cause is something biological," says Mazzola. "That cause may vary from place to place. In the Northeast, for example, nematodes may cause a problem. Here in Washington, specific groups of fungi seem to be the primary culprits," he says.

Methyl bromide is due to be phased out by 2005, and other common pesticides used in Northwest orchards may also be taken off the shelf because of environmental concerns. For that reason, and to support the region's organic growers, Mazzola is looking for a nonchemical approach to prevent replant disease.

The search is becoming more urgent all the time. "Years ago, growers might have left an orchard in for several decades," Mazzola says. "But to meet market demands, some growers now pull out old orchards and plant new varieties much sooner."

Growers produce at least a dozen commercial varieties in Washington's billion-dollar-a-year apple industry. About half of the nation's apples are produced there on about 180,000 acres. About 10,000 acres of apples are replanted each year.

A Bigger Problem Over Time

If a new orchard is planted on ground that was previously used for something else, the detrimental fungi don't build up fast enough to hurt the trees before they get established. But if trees are planted into an existing or previous apple orchard, the fungal population prevents the young, new trees from growing well.

Scientists agree that chemicals exuded from plants affect the surrounding soil, thereby favoring specific populations of microorganisms. Although the specific chemicals have not been identified, Mazzola found that after an orchard has been in place about 3 years, apples promote a fungal population that can cause replant disease. He's studied 18 orchards in Washington, collaborating with Wenatchee Valley College and David Granatstein, director of Washington State University's Center for Sustainable Agriculture and Natural Resources in Wenatchee.

Now Mazzola is looking at how long wheat would have to be grown as a rotation crop to change the soil microbial community enough to stave off replant disease. Alternatively, he'll look at whether growing wheat as a cover crop in existing orchards can reduce fungal populations sufficiently to allow new trees to grow well. He doesn't anticipate that apple growers would harvest the wheat as a crop, but says that would be up to the individual.

Theoretically, if young trees are given a good start, they'll be able to grow—despite the deleterious fungi—when they're older. But Mazzola speculates that continuing to keep populations of these fungi low might improve yield, even in mature trees. Although greenhouse tests have indicated the strategy has merit, he doesn't advocate that growers abandon fungicides and rely on wheat until he has conclusive evidence in a field situation.

"Washington has a progressive apple industry, and they're really interested in this work," Mazzola says.

Next he'll try to identify why some wheat cultivars work while others have little or no effect. So far, he hasn't found any commonality among wheat types—such as hard red or soft white—only that some varieties provide a good environment for *P. putida* while others don't.

Technical Reports

USDA/EPA Methyl Bromide Working Group Report on Efficacy and Regulatory Issues of Telone

By Ken Vick (1), Peter Caulkins (2) and Barbara Zapp (3)

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The USDA/EPA Methyl Bromide Working Group was established in 1994 by USDA Deputy Secretary Rominger and U.S. Environmental Protection Agency (EPA) Administrator Browner to coordinate the USDA's research program with the EPA's registration programs. This Working Group was referred to in a letter from Deputy Secretary Rominger which appeared in the October 1999 issue of this newsletter. Recent activities of this group were also reviewed in that issue.

A Working Group meeting was held in Orlando, Florida, May 11, 2000, to discuss efficacy and regulatory issues of the Dow AgroSciences product, Telone. Many scientists report that Telone in combination with a herbicide to control weeds and chloropicrin to assist with soil pathogens provides efficacy approaching or equal to that of methyl bromide/chloropicrin. There are serious regulatory impediments to its use in Florida and this meeting was held to discuss strategies for Telone use which might enable farmers to make more extensive use of Telone as a methyl bromide alternative. Approximately 60 people attended the meeting, including: farmers; Federal, State and university agricultural scientists; extension agents; Federal, state and county environmental protection agency personnel; commodity representatives for the major horticultural crops in Florida; Dow AgroSciences technical representatives; and several members of the USDA/EPA MB Working Group.

Major Telone issues summarized by two major growers in Florida and southeastern states are as follows (the importance of each issue may vary with local conditions):

1. Personal Protection Equipment: Telone recently completed the USEPA reregistration process–which took over a decade to complete. The label for Telone requires that workers in the field wear complete protective clothing (moon suits), and full face respirators while fumigation is in progress. In the Florida farming system, plant beds are raised at the same time that fumigation takes place. This activity requires that as many as 40 workers be in the field during fumigation—all required to wear moon suits. Fumigation normally takes place in late summer when temperatures are often in the mid 90's (F). The required protective clothing is very hot under these conditions, and OSHA regulations will limit each worker to a few minutes of work per hour. Growers find this restriction to be economically unfeasible.

2. Broadcast Fumigation: This method involves fumigating the entire field (rather than just the plant beds) and forming the beds after the field entry waiting period is over. This has the advantage of greatly reducing the personnel (2 or 3) needed in the field during fumigation. This method was found to be less effective than bed fumigation (up to 40 percent reduction in efficacy). Research continues to determine the cause for the loss of efficacy.

3. Buffer Zone: For Telone, a 300 foot buffer zone (untreated area) between the treated area and any occupied dwelling is required. The Florida strawberry industry seems particularly vulnerable to the buffer zone restrictions because fields are typically small (averaging about 20 acres) and population densities are relatively high in the strawberry producing area. A 20-acre strawberry field with adjacent housing would only be able to treat about 8 acres because of buffer zone requirements. It is economically unfeasible with the cost of land and farming overhead for a strawberry farmer to fallow 12 out of 20 acres.

4. Consistent Efficacy: Tests in research plots and grower fields give results comparable to methyl bromide/chloropicrin in some tests, but other tests show somewhat lower efficacy. A grower with an extensive alternatives testing program estimated the efficacy reduction to be about 4 percent for his tests. Also, one methyl bromide/chloropicrin fumigation is typically used for 2 crops (double cropping) but there has been little research on effectiveness of Telone-based systems for effectiveness on the second crop. Application through drip irrigation has been effective in California and more research is planned for Florida to increase effectiveness and possibly reduce atmospheric emissions. But cost of the drip tape, poor quality of the water (water emitters tend to stop up when water quality is not good) and different soil types in Florida, may make this procedure less workable than in California.

5. Herbicide Partner: Telone has minimal effect on weeds and will not control nutsedge, probably the number one problem in Florida. There is no effective herbicide registered to partner with Telone/chloropicrin for peppers, a major crop in Florida. Weed control will also be a problem in strawberries, cucumbers and eggplants.

6. Label Changes for Tillam: On a brighter note, data collected from research plots using Telone/chloropicrin along with Tillam for weed control indicates this system provides efficacy approaching that of methyl bromide/chloropicrin for tomatoes. Tillam, however, is only provisionally approved for hand-transplanted tomatoes contingent on research by the registrant (registrant has 2 years) to produce data to address worker safety issues for Tillam.

These issues serve to illustrate the complexity of replacing methyl bromide in an era of low farmer profits and intense competition from commodities imported from Mexico and elsewhere. Telone has some pronounced advantages: it is an excellent nematicide—probably better than methyl bromide—and nematodes are a major pest in Florida with its warm winters and sandy soils—and Telone has completed the reregistration process—many alternatives being investigated by researchers are not registered—a process that even with a willing, well-financed registrant, requires multiple years.

The goal of the USDA/EPA Methyl Bromide Working Group is to make available to growers and other methyl bromide susers the widest array of alternatives possible within the time constraints of the phaseout period and the requirement that pesticides be usable in an environmentally friendly manner. Research will continue to develop methodologies that will allow a greater use of Telone and other chemical and nonchemical alternatives to methyl bromide. Future updates of the MB Working Group will focus on other alternatives and research efforts to make them more effective and available to farmers.

Nematicidal Properties of Iodinated Hydrocarbons

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Methyl bromide has been used as a fumigant against a variety of pest species that attack crops, perishable commodities, stored grains, wood products, and structures. Unfortunately, methyl bromide has a number of undesirable characteristics, including destruction of the Earth's ozone layer, and will eventually be removed from general use. The need for effective fumigants, however, remains. We have investigated the insecticidal and nematicidal properties of several low molecular weight [C1–C8] iodinated hydrocarbons to determine their potential as soil and structural fumigants. Iodinated hydrocarbons are volatile, toxic, and do not affect ozone.

We examined the insecticidal properties of iodinated hydrocarbons in laboratory experiments with American, *Periplaneta americana,* and German, *Blattella germanica,* cockroaches. Groups of cockroaches were confined in 0.95-liter glass jars with a small cotton ball. Exactly 50 µl of a test chemical was applied to the cotton ball and the jar was sealed. Knockdown, defined as the inability to walk in a coordinated manner, and mortality were assessed every 15 minutes for the first hour and hourly thereafter for 8 hours and again after 24 hours. Mono-iodo compounds [C1–C3] were generally more effective than di-iodo compounds against both species. Iodomethane, iodoethane, and 1-iodopropane knocked down 100 percent of cockroaches within 1 hour after treatment and caused 100 percent mortality within 2 hours. Di-iodomethane knocked down ≈40 percent of cockroaches within 1 hour and killed 100 percent of cockroaches by 4 hours. American cockroaches were more sensitive to 1,6-diiodohexane and 1,5-diiodopentane and iodoform than German cockroaches. Diiodomethane and 1,4-diiodobutane were repellent to German cockroaches. Several diiodinated compounds did not cause mortality even after 24 hours of continuous exposure.

We also assessed the nematicidal properties of iodinated hydrocarbons in greenhouse experiments with field soil infested with *Meloidogyne arenaria* and *Heterodera glycines*. Chemicals were added directly to infested soil at rates <100 mg/Kg soil. Treated soil was kept moist (approximately 60 percent field capacity) and uncovered for 7–10 days when samples were collected and the pots were planted with 'Brim' soybean, *Glycine max*. Diiodo compounds were generally more effective in controlling nematodes and reducing root gall formation by *M. arenaria* than the monoiodo hydrocarbons; however, there were significant differences in nematicidal properties among the diiodo compounds. 1,2-diiodoethane (C2), 1,3-diiodopropane (C3), 1,4-diiodobutane (C4), 1,5-diiodopentane (C5), 1,6-diiodohexane (C6), and 1,8-diiodobutane were applied to soil at rates of 2.5, 5.0, 7.5, and 10 mg/Kg soil. All rates of C2 and C8 were ineffective in reducing *M. arenaria* juvenile (J2) populations in pre-plant samples. This was also true for C2 and J2 populations of *H. glycines;* however, C2 rates ≥5.0 mg suppressed J2 populations of *H. glycines*. C3, C4, C5, and C6 applied at rates of ≥5.0 mg virtually eliminated J2 populations of *M. arenaria* and *H. glycines* in pre-plant samples. *H. glycines* J2 numbers in final soil samples were generally inversely related to rates for C3–C8. This pattern of suppression in J2 numbers was also applicable to *M. arenaria* in the final soil samples, but only for C3–C6. C2 applications resulted in either no change in *H. glycines* J2 numbers or in increased numbers. Final numbers of *M. arenaria* J2's in soil increased directly with C2 dosage, but did not change significantly in response to C8 rates. Applications of C3–C6 to soil increased shoot weights in a manner directly related to dosages, but in a curvilinear pattern. Number of galls/g root and root-knot index values declined proportionately to increasing rates of C3–C6, but the opposite was observed for C2 and C8. Results showed that C3–C6 were the most nematicidal of the iodinated hydrocarbons tested.

The toxicity of iodinated hydrocarbons differs somewhat between insects and nematodes, indicating possible different modes of action of iodinated hydrocarbon compounds between phyla. Because of their chemical properties, most notably their solubility, low molecular weight mono- and di-iodinated hydrocarbons have the potential to be mixed to make an effective insecticidal and nematicidal formulation that performs as well as methyl bromide against insects and nematodes.

Upcoming Events

Professional Analytical and Consulting Services, Inc. Call for presenters and vendors for the 8th Annual International Activated Carbon Conference, Pittsburgh, Pennsylvania, September 21–22, 2000. Contact Barbara Sherman or Dr. Henry Nowicki, 409 Meade Dr., Corapolis, PA 15108; phone 800–367–2587, e-mail HNPACS@aol.com.

Methyl Bromide Alternatives Outreach. 2000 International Research Conference on Methyl Bromide Alternatives and Emissions Reduction, Clarion Plaza Hotel, Orlando, Florida, November 6–9, 2000. Contact Rosemary Obenauf; phone 559–447–2127, e-mail robenauf@agrc.cnchost.com.